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Heavy Metal Pollution and Major Nutrient Elements Assessment in the Soils of Bogra City in Bangladesh

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Abstract: Bogra city is highly susceptible to environmental pollution due to over population, rapid industrialization and urbanization during the last decades. A study was conducted to determine heavy metals (Cu, Zn, Pb, Cr, Cd and Ni) pollution level and physicochemical properties in the soils of Bogra city. The concentrations of heavy metals in 14 soil samples were determined by using an Atomic Absorption Spectrophotometer (AAS). The mean total concentrations of Cu, Zn, Pb, Ni, Cr and Cd in soil samples were 131.87, 28.46, 9.60, 7.56, 4.05 and 6.95 µg g^{-1}, respectively. Among the major nutrient constituents in soil, the range of N, Ca and Mg were 0.08-0.14, 0.01-0.40 and 0.01-0.22 wt %, respectively and the average concentration of Na, K, P and S were 152.49, 63.63, 25.75 and 17.70 µg g^{-1}, respectively. Considering pollution load index (PLI), out of 14 locations, 10 sites had the value >1.0 indicates pollution load in the respective sites. The study revealed that the contamination factor for Cd and Cu was several times higher compared to Zn, Pb, Cr and Ni. Similarly, the geoaccumulation index (I_{geo}) values also indicates strongly and uncontaminated to moderately pollution level of Cd and Cu, respectively. This study revealed that Cd and Cu are the major pollutants in soils of different areas of Bogra city in Bangladesh.

Keywords: Soil Contamination; Trace Metals; Pollution; Nutrients; Pollution Load Index;

1. INTRODUCTION

High concentrations of heavy metals in soil can negatively affect crop growth, as these metals interfere with metabolic functions in plants, including physiological and biochemical processes, inhibition of photosynthesis, respiration and degeneration of main cell organelles, even leading to death of plants [1-4]. Soil contamination with heavy metals may also cause changes in the composition of soil microbial community, adversely affecting soil characteristics [5-6]. Although, some heavy metals, such as Cu and Zn, have known functions as micronutrients in plants [7] , they can be toxic at high concentrations [8]. These phytotoxic effects of heavy metals depend on metal concentration, plant species, pH and other soil

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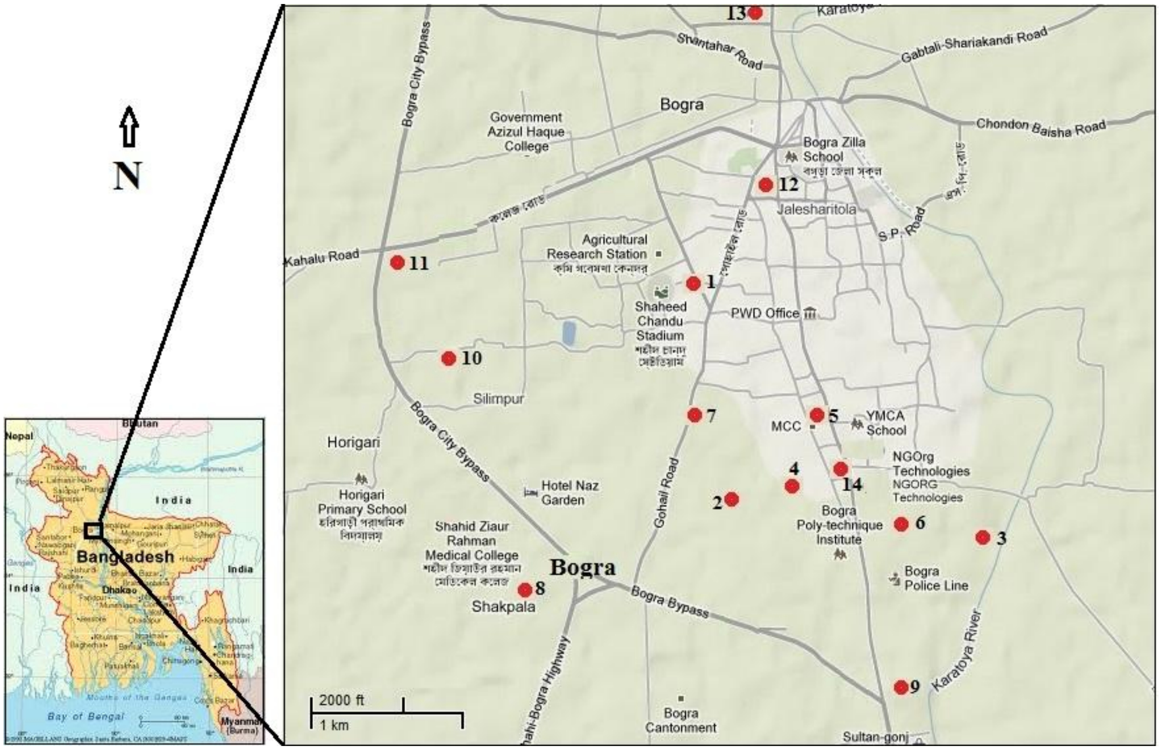

Figure 1. Location of soil sampling sites of Bogra City

factors [9-11]. Due to heavy metal stress, the production of reactive oxygen species (ROS) causes damage to the plant cells [12]. Plants grown in heavy metals rich soil results in transfer of substantial amount of potentially toxic metals into the food chain [13-15]. The loading of heavy metals often lead to degradation of soil health and contamination of food chain mainly through the crops grown on such soils, and has significant implications for human health.

Anthropogenic inputs of heavy metals are associated with natural sources, industrialization and agricultural practices. Generally, the distribution of heavy metals in soil is influenced by the nature of parent materials, climatic conditions and their relative mobility depending on soil parameters, such as mineralogy, texture and classification of soil [16-17]. Some physicochemical properties of soils such as pH and organic carbon (OC) are important parameters that control the accumulation and the availability of heavy metals in the soil environment. The knowledge of heavy metal accumulation in soil, the origin of heavy metals and their possible interactions with soil components are priority objectives in many environmental monitoring studies. Heavy metals pollution of urban soils has raised public and government attention towards implementation of strict polices and laws to prevent further environmental degradation. Urban soils that play an important role in maintaining environmental quality receive heavy metals from natural as well as anthropogenic activities. On the other hand, several vegetables and fruit plantations are usually grown in the fallow lands of the city area. For their balanced nutrition assessment of available essential plant nutrients are also very important. Considering the above facts, the present study was planned to assess some heavy metal pollution level and major nutrient status in soils of Bogra city in Bangladesh.

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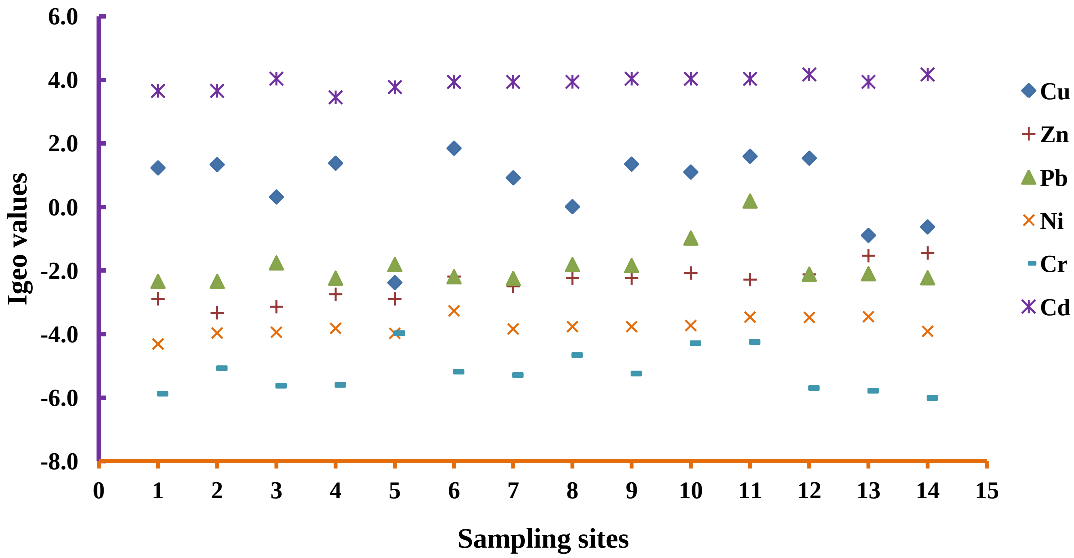

Figure 2. Geoaccumulation index (I_{geo}) of different heavy metals in different soil samples collected from Bogra city, Bangladesh

2. MATERIALS AND METHODS

2.1 Description of the study area

Bogra district has an area of 2898.25 sq. km, located in between 24°32´ and 25°07´ north latitudes and in between 88°58´ and 89°45´ east longitudes, with annual average temperature maximum 34.6°C and minimum 11.9°C, and annual rainfall 1610 mm. Bogra is one of the newly industrial based areas of Bangladesh, which is highly susceptible to environmental pollution due to over population, rapid industrialization and urbanization in last 10 years. There are several types of industrial units including aluminum factory, tannery, pharmaceutical industry, cosmetics industry, diesel plant, ceramics factory, packaging industry, brick field, garments and many others [18].

2.2 Collection and preparation of samples

Total 14 soil samples were collected at depth of 0-30 cm from Bogra city, Bangladesh during October to November 2010 as described in Fig. 1.). Three sub-samples were collected from every point and combined together to made one composite sample. The sediment samples were taken at a depth of 0-15 cm. The sample mass collected in each case was about 500 g. Samples were oven dried at 45°C for 48 hrs and ground using mortar and pestle and sieved (aperture 125 µm). The lower particle size fraction was homogenized by grinding in an agate mortar and stored in glass bottles for chemical analyses.

2.3 Determination of physicochemical properties and major nutrients content in soils

The pH was measured in 1:2.5 soils to water ratio by using a Jenway-3505 pH meter. The suspension was allowed to stand overnight prior to pH determination. The electrical conductivity (EC) was measured in the saturated extract of the soils, using a WTW LF 521 EC meter. The textural class of the soils was measured by plotting the results on a triangular diagram following USDA system designed by Marshall [19]. The organic carbon (OC) was measured by the wet oxidation method of Walkley and Black [20]. Major nutrient elements (P, K, S, Ca and Mg) in soil samples were determined in the laboratory of the Department of Agricultural Chemistry, BAU by adopting the procedures outlined by Jackson, [21] and Tandon, [22].

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Table 1. Physicochemical properties and textural class of soil samples collected from different areas of Bogra city, Bangladesh.

Sample ID	pH	EC (μS cm^{-1})	OC (%)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Textural class of soil
1	4.74	96	0.81	1.40	78	14	8	Sandy loam
2	4.77	193	0.85	1.47	64	28	8	Sandy loam
3	4.75	52	0.47	0.82	34	52	14	Silt Loam
4	4.63	272	2.11	3.66	36	54	10	Silt Loam
5	4.66	102	0.83	1.44	34	52	14	Silt Loam
6	4.50	123	0.17	0.29	30	44	26	Loam
7	5.12	275	0.42	0.72	28	62	10	Silt Loam
8	4.68	53	1.02	1.76	32	64	4	Silt Loam
9	4.88	386	0.60	1.04	30	64	6	Silt Loam
10	4.79	524	0.92	1.60	34	54	12	Silt Loam
11	5.05	625	1.23	2.12	34	52	14	Silt Loam
12	5.58	358	0.23	0.39	38	54	8	Silt Loam
13	5.50	425	1.55	2.68	36	52	12	Silt Loam
14	5.20	429	1.23	2.12	32	66	2	Silt Loam
Range	4.5-5.6	52-625	0.17-2.11	0.3-3.7	28-78	14-66	2-26	Sandy loam-
Mean	4.92	279.5	0.89	1.54	38.57	52.43	0.57	Silt Loam

2.4 Determination of heavy metals concentration in soil samples

Total concentrations of *Cu, Zn, Pb, Cd, Ni and Cr* in soil samples were determined by using an atomic absorption spectrophotometer (AAS), equipped with single elements hollow-cathode lamps at the wavelengths of 324.7, 213.9, 283.3, 228.8, 232.0 and 357.9 nm, respectively. The instrument was operated at maximum sensitivity with an air-acetylene flame. Lamp intensity and bandpass were used according to the manufacturer's recommendations. For the determination of total heavy metals concentration, exactly 1.00 g of powdered soil sample was digested with aqua regia (HNO_3: HCl = 1: 3). All chemicals and reagents were of analytical reagent grade quality (Merck, Germany). Before use, all glass and plastic ware were soaked in 14% HNO_3 for 24 hrs. The washing was completed with distilled water rinse.

2.5 Determination of geoaccumulation index (I_{geo})

The geoaccumulation index (I_{geo}) values were calculated for ***Cu, Zn, Pb, Cd, Ni and Cr*** as introduced by Muller [23] is as follows-

$$I_{geo} = \log_2 (C_n / 1.5 \times B_n)$$

Where C_n is measured concentration of metal in the soil, and B_n is the geochemical background for the same element which is either directly measured in precivilization soils of the area or taken from the

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literature (average shale value described by Turekian and Wedepohl, [24]. The factor 1.5 is introduced to include possible variations of the background values that are due to lithologic variations. According to Muller [23], there are seven grades or classes of the geoaccumulation index. Class 0 (practically uncontaminated/unpolluted): $I_{geo} < 0$; Class 1 (Uncontaminated to moderately contaminated): $0 < I_{geo} < 1$; Class 2 (moderately contaminated): $1 < I_{geo} < 2$; Class 3 (moderately to strongly contaminated): $2 < I_{geo} < 3$; Class 4 (strongly contaminated): $3 < I_{geo} < 4$; Class 5 (strongly to extremely contaminated): $4 < I_{geo} < 5$; Class 6 (extremely contaminated): $I_{geo} > 5$, which is an open class and comprises all values of the index higher than Class 5.

2.6 Assessment of pollution load index (PLI)

The pollution load index (PLI) proposed by Tomlinson *et al*. [25] has been used in this study to measure PLI of soils of Bogra in Bangladesh. The PLI for a single site is the *n*th root of *n* number of multiplied together contamination factor (CF) values. The CF is the quotient obtained as follows:

$$CF = C_{\text{Metal concentration}} / C_{\text{Background concentration of the same metal}}$$

and

$$\text{PLI for a site} = n\text{th} \sqrt{CF_1 \times CF_2 \ldots \times CF_n},$$

where, n equals the number of contamination factors and sites, respectively.

A number of contamination factors are derived for different heavy metals at each site, and a site pollution index may then be calculated by taking the five highest contamination factors and deriving the fifth root of the five factors multiplied together. Such site indices can be treated in exactly the same way to give a zone or area index [25].

3. RESULTS AND DISCUSSION

3.1 Physicochemical Properties of Soil

Mechanical analysis of soil is the process of determining the relative percentage of sand, silt and clay eventually to find out the textural classes. The study results indicated that about 78% sampling locations has silt loam textural class which is sensitive to accumulate heavy metals (Table 1). The pH values of soil samples ranged from 4.50 to 5.58 at 0-30 cm depth (Table 1). All soils were acidic in nature which may enhance heavy metal distribution and availability to the plants. The EC of soil ranged from 52 to 625 $\mu S\ cm^{-1}$. According to Costa *et al*. [26], high EC value in soil may be due to high quantities of salt, solid wastes and effluents of tannery and other industries. The organic carbon content ranged from 0.17 to 2.1%. The deposition and decomposition of huge quantities of solid wastes and sewage sludge might be responsible for the organic matter enrichment in this soil.

3.2 Major Nutrient Constituent in Soil

The concentration of N in soil samples collected from different areas of Bogra city was within the range of 0.08-0.14% with an average value of 0.10% (Table 2). The content of exchangeable Ca and Mg in soil samples varied from 0.09 to 0.40 and 0.01-0.22%, respectively (Table 2). The variations in exchangeable Ca and Mg content might be due to deposition and decomposition of solid wastes, origin and nature of soil parent materials, slope position and water movement within the soils. The mean concentration of exchangeable Na and were 152.49 and 63.63 $\mu g\ g^{-1}$, respectively (Table 2). The variations in exchangeable Na and K content might also be due to deposition and decomposition of solid

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Table 2. Major nutrient concentrations in soil samples collected from different areas of Bogra City, Bangladesh.

Sample ID	Total N (%)	Major available nutrient concentrations					
		Ca (%)	Mg (%)	Na ($\mu g\ g^{-1}$)	K ($\mu g\ g^{-1}$)	P ($\mu g\ g^{-1}$)	S($\mu g\ g^{-1}$)
1	0.11	0.09	0.01	212.25	52.00	22.48	1.29
2	0.08	0.14	0.03	44.980	52.00	19.34	0.53
3	0.11	0.26	0.12	65.870	21.46	2.54	1.29
4	0.14	0.20	0.06	118.12	174.14	7.54	24.02
5	0.11	0.11	0.02	55.430	21.46	21.84	Trace
6	0.11	0.29	0.14	76.330	123.25	9.33	2.80
7	0.08	0.24	0.11	97.220	52.00	7.54	15.68
8	0.08	0.14	0.04	139.01	21.46	10.40	Trace
9	0.11	0.38	0.19	159.91	21.46	9.69	18.71
10	0.11	0.26	0.11	223.04	82.53	58.67	17.95
11	0.08	0.40	0.22	347.98	102.89	126.60	44.47
12	0.08	0.36	0.19	191.26	72.35	45.08	29.32
13	0.11	0.19	0.07	159.91	41.81	9.60	28.56
14	0.11	0.20	0.08	243.49	52.00	9.69	27.80
Range	0.08-0.14	0.01-0.40	0.01-0.22	44.98-347.98	21.46-174.14	2.54-126.6	Trace-44.47
Mean	0.10	0.23	0.10	152.49	63.63	25.75	17.70

wastes, temperature, rainfall, topography and others. Ahmed *et al*. [26] reported that K content in non-irradiated sewage sludge was 0.61 meq $100g^{-1}$ and in irradiated sewage sludge was 0.56 meq $100g^{-1}$. The available phosphorus and sulphur content of the soil samples collected from different sites of Bogra were within the range of 2.54 to 126.6 and trace to 44.47 $\mu g\ g^{-1}$, respectively (Table 2). Bhuiyan [28] reported that the available P content at different soil series of Bangladesh range from 2.2 to 140 $\mu g\ g^{-1}$ with the mean value of 21.2 $\mu g\ g^{-1}$.

3.3 Heavy Metals in Soil Samples

The concentration of Cu in soils ranged between 12.84 to 245.35 $\mu g\ g^{-1}$, having an average value of 131.87 $\mu g\ g^{-1}$ (Table 3). Kabata and Pendias [29] reported that the maximum acceptable concentration of Cu in the soils for crop production is less than 100 $\mu g\ g^{-1}$. The present study showed that for most soils

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the average Cu concentration were higher compared with several other industrial areas in home, abroad and geochemical background value of continental crust (Table 4). The present study showed that in most cases the average Zn concentrations in soils collected from different areas of Bogra city were lower compared with several industrial areas in Bangladesh and other countries of the world as well as geochemical background value of continental crust (Table 4). The status of Pb in soils ranged between 5.88 to 34.25 μg g^{-1}, having an average value of 9.6 μg g^{-1} (Table 3). The concentrations of Pb in the study areas were lower than maximum acceptable concentration of 50 μg g^{-1} for crop production[29]. The concentration of Cr in soils ranged between 2.05 to 8.48 μg g^{-1}, having an average value of 4.05 μg g^{-1} (Table 3). The concentration of Ni in soils ranged between 5.05 to 10.48 μg g^{-1}, having an average value of 7.56 μg g^{-1}. It is apparent from results that the average Pb, Ni and Cr levels in soils collected from different areas of Bogra city were very much lower compared with several other industrial areas in Bangladesh and in the world as well as geochemical background value of continental crust. The total concentration of Cd found in soils of Bogra city are presented in Table 3. The level of Cd in soils ranged between 5.00 to 8.25 μg g^{-1}, having an average value of 6.95 μg g^{-1}. The observed concentration of Cd in

Table 3. Total heavy metals concentrations in soil samples collected from different areas of Bogra City, Bangladesh.

Sample ID	Total heavy metal concentrations (μg g^{-1})					
	Cu	Zn	Pb	Ni	Cr	Cd
1	159.14	19.00	5.88	5.05	2.25	5.75
2	171.21	14.00	5.88	6.43	3.93	5.75
3	84.14	16.00	8.81	6.55	2.68	7.50
4	176.38	21.00	6.31	7.13	2.73	5.00
5	12.84	19.00	8.50	6.38	8.48	6.25
6	245.34	31.00	6.50	10.48	3.65	7.00
7	128.10	25.00	6.25	7.03	3.38	7.00
8	68.10	30.00	8.50	7.38	5.25	7.00
9	172.93	30.00	8.31	7.38	3.50	7.50
10	145.34	33.50	15.19	7.58	6.80	7.50
11	205.69	29.00	34.25	9.10	7.00	7.50
12	197.07	32.50	6.88	9.05	2.55	8.25
13	36.21	49.00	6.94	9.18	2.40	7.00
14	43.62	52.00	6.35	6.68	2.05	8.25
Range	12.8-245.4	14-52	5.9-34.3	5.1-10.5	2.1-8.5	5-8.3
Mean	131.87	28.46	9.60	7.56	4.05	6.95

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Table 4. Average heavy metal concentrations (μg g^{-1}) in the collected soil samples of different areas of Bogra city, Bangladesh compared with other industrial areas of the world.

Heavy metals	SP	FCC	SICZI	UPI	DCA	ISG	GBCC	Present study
Cu	26.85	40.77	29.87	42.90	75.04	36.18	55.00	131.87
Zn	94.2	159.85	49.90	159.90	103.34	176.66	70.00	28.46
Pb	121.4	40.59	15.72	38.30	3.84	27.94	75.00	9.60
Ni	85.46	21.92	154.00	nd	nd	nd	12.50	7.56
Cr	155.0	nd	nd	2652.3	32.25	29.20	100.0	4.05
Cd	36.80	0.37	nd	nd	0.52	0.40	0.20	6.95
Ref	[32]	[33]	[34]	[35]	[36]	[37]	[38]	

SP = Sialkot, Pakistan;
FCC = Fuyang County China;
SICZI = Shiraz industrial complex zone, Iran;
UPI = Uttar Pradesh, India;
DCA =Dhaka City Area;
ISG = Industrial Sites of Gazipur;
GBCC = Geochemical background (continental crust) and
nd= not determined.

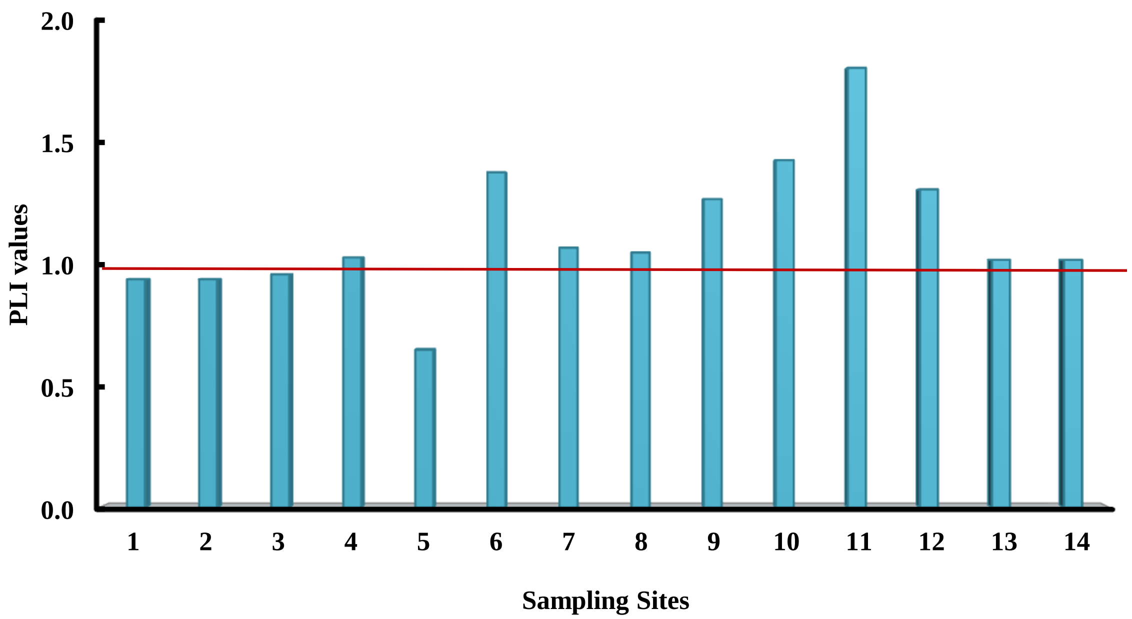

Figure 3. Pollution Load Index (PLI) values of different sampling sites

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soils were higher than the maximum acceptance concentration of 5 μg g^{-1} for food crop production [30]. Barman and Lal [31] found that the Cd concentration of the industrially polluted soils were 6.11±1.65 μg g^{-1} of West Bengal, India.

3.4 Assessment of Pollution Level

The geoaccumulation index (I_{geo}) introduced by Muller [23] was used to assess heavy metal pollution in soils of Bogra city. The calculated I_{geo} for heavy metals of soils collected from different areas of Bogra city, and their corresponding contamination intensity are illustrated in Fig. 2. Considering the I_{geo} values for Cd, all sites exhibited values $3 < I_{geo} < 4$, indicating strongly contaminated soil. On the other hand, the I_{geo} values for Pb of sample ID 11 was 0.19 which exhibited class-1, indicating unpolluted to moderately polluted soil quality. In case of Cu, out of 14 locations, 11 sites exhibited values $0 < I_{geo} < 2$, indicating uncontaminated to moderately polluted soil.

3.5 Pollution load index (PLI)

While computing the contamination factor (CF) for pollution load index (PLI) of soils of the study area, average shale value for each heavy metal described by Turekian and Wedepohl, [24] were considered as background concentration because there are no geochemical background data available for the studied region. The concept of a baseline is a fundamental issue to the formation of a PLI [25]. The PLI values ranged from 0.65-1.81 for soils of 14 locations of different areas of Bogra city (Fig. 3). The index as presented provides a simple and comparative means for assessing a site or estuarine quality: a value of zero indicates perfection, a value of one that only baseline levels of pollutants are present, and values above one would indicate progressive deterioration of the site and estuarine quality [25]. However, out of 14 locations, 10 sites had the value >1.0 indicates pollution load in the respective sites.

4. CONCLUSION

The present study determined some heavy metal concentrations and major nutrient elements in soils collected from Bogra city in Bangladesh. The calculated geoaccumulation index (I_{geo}) values for Cd, 100% sites exhibited I_{geo} class 4, indicating strongly polluted soil quality. The computed I_{geo} classes for Cu were 0-2, indicating uncontaminated to moderately polluted soil quality of the study area. Considering PLI, out of 14 locations, 10 sites had the value >1.0 indicates pollution load in the respective sites. The present study also revealed that the average Cd and Cu concentrations in collected soils were higher compared with several other industrial areas in Bangladesh and other countries of the world as well as geochemical background values of continental crust. So, it can be inferred from the study results that Cd and Cu contamination may lead to a potential danger for the health of human, animal and aquatic populations in the vicinity of the sampling sites. On the other hand, the study results also revealed that among the major soil nutrients the average total N and S content in soils of Bogra city was very low for crop production. The overall scenario of heavy metals concentration and major nutrient status of soils of different industrial areas of Bogra city was not at all satisfactory and it would have bad impact on the surrounding environment. However, to protect the ecology and environment as a whole of the study area following attempts should be taken by the appropriate authority: (i) identification of the origin and potential sources of heavy metals in the study area and accordingly local authority or Government of Bangladesh will have to take necessary action, (ii) industrial effluents and municipal wastes should not be directly discharged to any open field or water sources and must be treated before dumping, (iii) national and community level bodies should be formed and validated to monitor soils and different water sources, and the results use to determine anti-pollution measures, operating permits and actions (including legal actions) against offending industries, and finally (iv) to avoid any kinds of pollution, consciousness is the best policy, so people should be aware to their work and increase awareness among the industrialists about the pollution problem and their legal and social responsibility to prevent it.

REFERENCES

[1] Atafar, Z.; Mesdaghinia, A.; Nouri, J.; Homaee, M.; Yunesian, M.; Ahmadimoghaddam, M.; Mahvi, A.H. Effect of fertilizer application on soil heavy Metal concentration. *Environ. Monit. Assess.,* 2010,160, 83.

[2] Garbisu C.; Alkorta, I. Phytoextraction: A cost effective plant-based technology for the removal of metals from the environment. *Bioresearch Technology,* **2001**, 77(3), 229-236.

[3] Schmidt, U. Enhancing Phytoremediation: The effect of chemical soil manipulation on mobility, plant accumulation, and leaching of heavy metals. *Journal of Environmental Quality*, **2003**, 32, 1939-1954.

[4] Schwartz, C.; Echevarria, G.; Morel, J.L. Phytoextraction of cadmium with Thlaspi caerulescens. *Plant and Soil*, **2003**, 249(1), 27-35.

[5] Giller, K.E.; Witter, E.; McGrath, S.P. Toxicity of heavy metals to microorganism and microbial processes in agricultural soils: A review. *Soil Biology and Bichemistry*, **1998**, 30(10-11), 1389-1414.

[6] Kurek, E.; Bollag, J.M. Microbial immobilization of cadmium released from CdO in the soil. *Biogeochemistry,* **2004**, 69(2), 227-239

[7] Sharma, C.P. *Plant Micronutrient*. First Edition. Science Publisher, New Hampshier, USA. 2006, 5-10.

[8] Pandey, S.N. Growth and biochemical changes in pulse seedlings irrigated with effluent from electroplating industry. *Journal of Applied Biological Science*, 2008, 34, 79-82.

[9] Barman, S.C. Sahu, R.K.; Bhargava, S.K.; Chatterjee, C. Distribution of heavy metals in wheat, mustard and weeds grown in field irrigated with industrial pollutants. *Bulletin of Environmental Contamination and Toxicology*, 2000, 64, 489-496.

[10] Chandra, R.; Kumar, K.; Singh, J. Impact of anaerobically treated and untreated (raw) distillery effluent irrigation on soil microflora, growth, total chlorophyll and protein contents of *Phaseolus aureus* L. *Journal of Environmental Biology*, 2004, 25, 381-385.

[11] Mohiuddin, K.M.; Otomo, K.; Ogawa, Y.; Shikazono, N. Seasonal and spatial distribution of trace elements in the water and sediments of the Tsurumi River in Japan. *Environ Monit Assess*, 2012, 184, 265-279.

[12] Gajewska, E.; Sklodowska, M.; Slaba M.; Mazur, J. Effect of nickel on antioxidative enzyme activities, proline and chlorophyll contents in wheat shoot. *Biologia Plantarum*, 2006, 50, 653-659.

[13] Pandey, S.N.; Nautiyal, B.D. Electroplating effluents and its irrigational impact on seedling growth of pigeon pea and maize. *Journal of Industrial Botanical Society*, 2008, 87, 1-6.

[14] Agoramoorthy, G.; Chen, F.A.; Venkatesalu, V.; Shea, P.C. Bioconcentration of heavy metals in selected medicinal plants of India. *Journal of Environmental Biology*, 2009, 30, 175-178.

[15] Naaz, S.; Pandey, S.N. Effects of industrial waste water on heavy metal accumulation, growth and biochemical responses of Lettuce (*Lactuca sativa* L.). *Journal of Environmental Biology*, 2010, 31, 273-276.

[16] Krishna, A.K.; Govil, P.K. Soil contamination due to heavy metals from an industrial area of Surat, Gujarat, Western India. *Environmental Monitoring and Assessment*, 2007, 124, 263-275.

[17] Mohiuddin, K.M.; Ogawa, Y.; Zakir, H.M.; Otomo, K.; Shikazono, N. Heavy metals contamination in the water and sediments of an urban river in a developing country. *Int. J. Environ. Sci. Tech.*, 2011, 8(4), 723-736.

[18] Anonymus. Cultural survey report of zila and upazilas of Bogra district. *Bogra District Administration*., 2007, 10-25.

[19] Marshal, T.J. Mechanical composition of soils in relation to field description of texture common wealth of

Australia, Council for Scientific and Industrial Research, Melbourne, Australia, Bulletin No. 224. 1947, 20.

[20] Walkley, A.; Black, I. A. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, 1934, 37, 29-38.

[21] Jackson, M.L. *Soil Chemical Analysis*. Prentice Hall, Inc., Englewood Cliffs, N.J. USA. 1962.

[22] Tandon, H.L.S. Methods of analysis of soils, plants, waters and fertilizers. Fertilizer Development and Consultation Organization, New Delhi, India. 1995, 87-92.

[23] Muller, G. Index of Geoaccumulation in sediments of the Rhine River. *Geojournal*, 1969, 2(3), 108-118.

[24] Turekian, K.K.; Wedepohl, K.H. Distribution of the elements in some major units of the earth's crust. *Geological Society of America Bulletin*, 1961, 72, 175-192.

[25] Tomlinson, D.C.; Wilson, J.G.; Harris C.R.; Jeffrey, D.W. Problems in the assessment of heavy metal levels in estuaries and the formation of a pollution index. *Helgoland Marine Research*, 1980, 33, 566-575

[26] Costa, C.N.; Castilhos, D.D.; Castilhos, R.M.V.; Konrad, E.E.; Passianoto C.C., Rodrigues, C.G. Tannery sludge effects on soil chemical properties, matter yield and nutrients uptake by soybean. *Revista Brasileira de Agrociencia*, 2001, 7(3). 189-191.

[27] Ahmed, S.; Rahman, S.M.; Ali, M.I.; Hossain M.B.; and Alam. T. Isotope-aided studies on the effects of radiation processed sewage sludge application on crop yields and bio-availability of heavy metals in Bangladesh soils. A report of Bangladesh Institute of Nuclear Agriculture, 1996, 1-9.

[28] Bhuiyan, N.I. Coordinated project on potassium studies report. Progress report (1987-88), Bangladesh Agricultural Research Institute, Joydebpur, 1988, 1-45.

[29] Kabata, P.A. and Pendias, H. Trace Elements in Soils and Plants, 2nd ed., CRC Press, London. 1992.

[30] NSWEPA. Interim Code of Practice for Use and Disposal of Biosolid Products. New South Wales Environment Protection Authrity, Sydney, NSW, Australia. 1994.

[31] Barman, S.C.; Lal, M.M. Accumulation of heavy metals (Zn, Cu, Cd and Pb) in soil and cultivated vegetables and weeds grown in industrially polluted fields. *Journal of Environmental Biology*, 1994,15(2), 107-115.

[32] Malik, R.N.; Jadoon W.A.; Husain, S.Z. Metal contamination of surface soils of industrial city Sailkot, Pakistan: a multivariate and GIS approach. *Journal of Environmental Geochemistry and Health*, 2010, 32: 179-191.

[33] Zhang, X.Y.; Lin, F.F.; Wong, M.T.F.; Feng X.L.; Wang. K. Identification of soil heavy metal sources from anthropogenic activities and pollution assessment of Fuyang County, China. *Environmental Monitoring and Assessment*, 2009, 154, 439-449.

[34] Shakeri, A., Moore F.; Modabberi, S. Heavy metal contamination and distribution in the Shiraz industrial complex zone soil, South Shiraz, Iran. *World Applied Sciences Journal*, 2009, 6(3), 413-425.

[35] Gowd, S.S.; Reddy, M.R.; Govil, P.K. Assessment of heavy metal contamination in soils at Jajmau (Kanpur) and Unnao industrial areas of the Ganga Plain, Uttar Pradesh, India. *Journal of Hazardous Materials*, 2010, 174, 113-121.

[36] Sultana, N. Nutrition content and heavy metal contamination in some roadside soils and grasses of Dhaka City, Bangladesh. M.S. Thesis, Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh, 2010.

[37] Sumi, S.S. Toxic metallic contamination in industrial wastewater and soils of some selected areas of gazipur, Bangladesh. M.S. Thesis, Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh 2010.

[38] Taylor, S. R. Abundances of chemical elements in the continental crust: a new table. *Geochimica et Cosmochimica Acta*, 1964, 28, 1273-1285.

The authors declare no conflict of interest